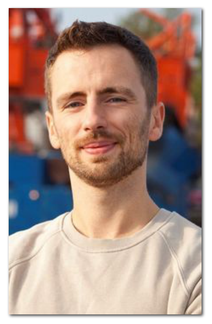


How will climate change affect the demersal fisheries of the North Sea?

Using a bio-economic model to predict climate-induced changes in fisheries profitability and identify pathways to nature-inclusive harvesting strategies

Erik Sulanke[1], Sarah Simons[1]

[1]Thünen Institute of Sea Fisheries, Bremerhaven, Germany

Introduction

The consequences of **climate change** are showing significant effects on marine life. At the same time, human use of the marine realm steadily intensifies, and **competition for space** has been emerging in recent years. Fisheries are heavily affected by the aforementioned factors and are a central pressuring factor on marine habitats. Therefore, developing **nature-inclusive harvesting** strategies for fisheries with respect to their complexity is emergent. We applied the **bio-economic optimization model FISHRENT** to simulate the **socio-economic consequences** of climate change scenarios on the **North Sea demersal fisheries**. Demersal fisheries comprise an essential part of the fishing fleets operating in the North Sea. They range from small-scale coastal vessels to highly mechanized industrial trawlers and contribute a significant share of the fisheries revenue generated in the region. We assembled specific and extensive catch, effort, and cost data for those fleets, which allowed us to **model changes** not only in **catch quantities** but also in the **cost structure** of those fleets, e.g., increased fuel use due to longer steaming times.

Results

Future scenarios

Global sustainability

- RCP2.6, SSP1
- Moderate fuel price increase (+2.59% p.a.)
- Low fish price increase (+ 0.6% p.a.)

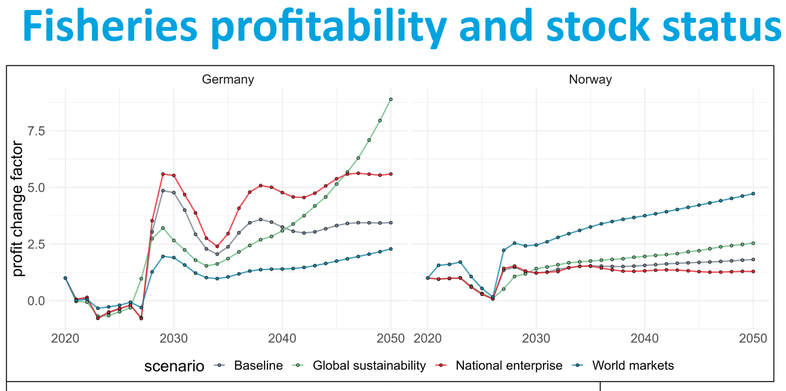
National enterprise

- RCP8.5, SSP3
- High fuel price increase (+4.47% p.a.)
- High fish price increase (+ 2.41% p.a.)

World markets

- RCP8.5, SSP5
- Low fuel price increase (+1.04% p.a.)
- Moderate fish price increase (+ 1.57% p.a.)

Fisheries profitability and stock status



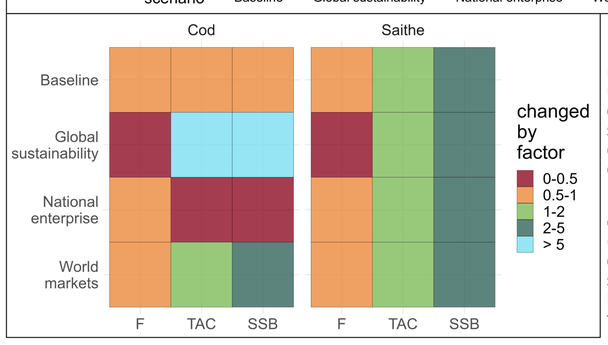


Figure 1 (above): Profitability of modelled segments under the three climate change scenarios. Y-axis displays change factor of profit.

Figure 2 (left): Change of fishing mortality (F), total allowable catch (TAC) and spawning stack biomass (SSB) under the three scenarios.

Material & Methods

Data collection

- **Catch**, **effort**, and **economic** data of multiple fleets collected
- **2018** until **2020** as reference years
- Catch and effort on **ICES-rectangle** aggregation
- **Novel fleet segmentation** approach applied
- 13 fleet segments from 5 nations

Model

- **FISHRENT** model is a **optimization** and **simulation** model
- Operating in **GAMS**, data prepared in R
- Norwegian and German fisheries simulated in the presented version[2]

Spatial distribution

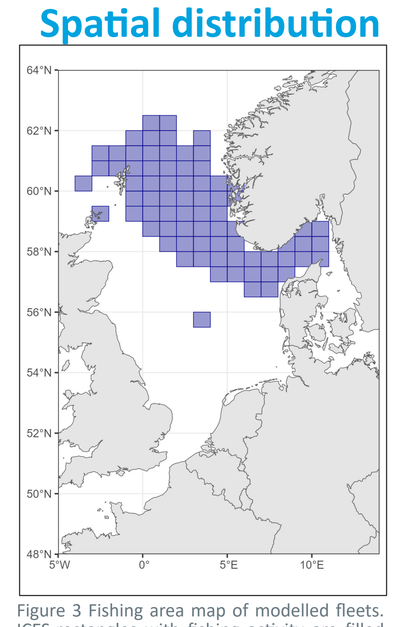
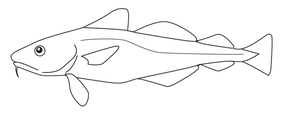


Figure 3 Fishing area map of modelled fleets. ICES-rectangles with fishing activity are filled blue.

Target species[3]

Saithe (*Pollachius virens*)



Cod (*Gadus morhua*)

Discussion & Outlook

Discussion

- **Effects** of climate change scenarios on the profitability depends on **cost structure** and **catch composition**
- German fleet has higher share of fuel costs and higher catshes of cod. **High profits** under Global sustainability are driven by **good** cod **stock status**
- Norwegien **fleet size** grows in all scenarios, German fleet size is always reduced. This is due to the Norwegian fleet being **more efficient** and **profitable**, but also depending less on the modelled target stocks
- **FISHRENT** only solves for **overall profit** of fleet segments. Profitable segments will always drive the model results

Competition for space & species distribution shifts

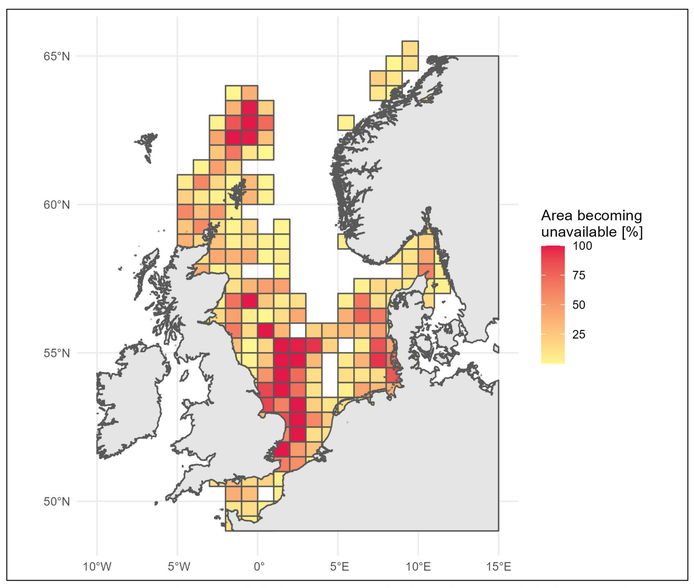


Figure 4: Potential loss of fishing grounds for demersal fisheries due to offshore windfarms and marine protected areas. The loss of area in percent is depicted by the color scale. Baseline of the projection is the full realization of all currently designated planning and priority areas.

- **Climate change** will have significant impacts on the **distribution** of target species
- We aim to include those shifts by adjusting species **catchability** as soon as the data is available
- Additionally, we will include **loss of fishing grounds** due to **offshore windfarms** and **marine protected areas**
- These need to be parametrized in accordance with the **scenarios**

Detailed information on the FutureMARES scenarios is available here:

[2]German economic fleet data was provided by Jörg Berkenhagen, Thünen Institute of Sea Fisheries, Bremerhaven, Germany. Norwegian fleet data was provided by Øystein Hermansen, Norwegian Institute of Food, Fisheries and Aquaculture Research, Tromsø, Norway.

[3]Species drawings were kindly provided by Kristina Barz and Christopher Zimmermann, Thünen Institute of Baltic Sea Fisheries.

For questions, remarks and discussion, please contact **erik.sulanke@thuenen.de**

[1]Thünen Institute of Sea Fisheries
Herwigstraße 31, 27572
Bremerhaven, Germany